(3)

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: TOP 4-2-505
2. GOVT ACCESSION NO.: AD-A127777
3. RECIPIENT'S CATALOG NUMBER:
4. TITLE (and Subtitle): US ARMY TEST AND EVALUATION COMMAND TEST OPERATIONS PROCEDURE "MINES AND DEMOLITIONS"
5. TYPE OF REPORT & PERIOD COVERED: Final
6. PERFORMING ORG. REPORT NUMBER:
7. AUTHOR(s):
8. CONTRACT OR GRANT NUMBER(s):
9. PERFORMING ORGANIZATION NAME AND ADDRESS: US ARMY ABERDEEN PROVING GROUND (STEAP-MT-M) ABERDEEN PROVING GROUND, MARYLAND 21005
10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: DARCOM-R 310-6
11. CONTROLLING OFFICE NAME AND ADDRESS: US ARMY TEST AND EVALUATION COMMAND (DRSTE-AD-M) ABERDEEN PROVING GROUND, MARYLAND 21005
12. REPORT DATE: 29 April 1983
13. NUMBER OF PAGES: 22
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office):
15. SECURITY CLASS. (of this report): Unclassified
15a. DECLASSIFICATION/DOWNGRADING SCHEDULE:
16. DISTRIBUTION STATEMENT (of this Report): Approved for public release; distribution unlimited.
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report):

DTIC ELECTE MAY 5 1983 A

18. SUPPLEMENTARY NOTES:
19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Blast Effects	Fuzes	Tanks
Demolitions	Mines	Vulnerability
Explosives	Sympathetic Detonation	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Provides tests for evaluating the performance characteristics of mines and demolitions. Describes safety evaluation, supplementary environmental and shock tests, and tests for weathering, fuze functioning, mine/fuze compatibility, effectiveness, bullet impact, blast sensitivity, sympathetic detonation, and parachute delivery. Discusses reliability, human factors and maintenance evaluations. Describes equipment and technique for determining burst height of bounding mines. Tabulates mine types and applications and physical characteristics of explosives. Not applicable to chemical mines.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

Encl 2 83 05 04 094

US ARMY TEST AND EVALUATION COMMAND
TEST OPERATIONS PROCEDURES

DPS'TE-RP-702-103
*Test Operations Procedure 4-2-505 — 29 April 1983
AD No.

MINES AND DEMOLITIONS

1. SCOPE. This TOP provides guidance for planning tests of mines and demolitions to assure their conformance with requirements documents. Subtests are designed to satisfy the requirements for the particular test item and test type (Development Test I, II, or III, or a customer test). These tests can be

*This TOP supersedes TOP 4-2-505 dated 22 April 1974.

selected from those listed in paragraph 4. This TOP covers simulated environmental tests, but does not include service phase tests or environmental tests at climatic test sites. Some background information on mines is contained in Appendix A.

Procedures contained herein have been generalized to accommodate the wide variety of materiel. Many other TOP's as cited herein contain information and engineering procedures useful in planning/conducting tests of at least some of the mine and demolition equipment, and therefore need to be considered for applicability.

In addition to developing plans for conducting tests, the safety of personnel involved in testing must be an integral part of the test planning process. The explosive loading of test items should be the minimum required to acquire the data and to meet the individual test objectives.

2. FACILITIES AND INSTRUMENTATION.

Equipment and facilities are covered in the references and in paragraph 4.

3. REQUIRED TEST CONDITIONS. These are described for each subtest in paragraph 4.

4. TEST PROCEDURES.

4.1 Initial Inspection. Conduct this subtest in accordance with TOP 4-2-502.[1*]

4.2 Physical Characteristics. Conduct this subtest in accordance with TOP 4-2-500.[2]

4.3 Safety Evaluation. Before undergoing other tests described in this TOP and before being released for operational testing, the test item must have successfully completed a safety evaluation. This consists of a number of tests designed to assure safe handling and transportation of the item under various conditions. These include mechanical shock, transportation vibration, and other environmental tests that have safety implications. The scope of tests falling under the safety evaluation, e.g., high and low temperature tests, is usually adequate for evaluating the effect of conditions under study, and these tests normally do not have to be expanded during the remainder of the test program. Safety evaluation tests are covered by TOP 4-2-502. A typical evaluation program consists of the following:

- Design review; adequacy of safety features
- Confirmation of functioning loads (when applicable; para 5.2 of TOP 4-2-502)
- Special sensitivity tests (para 5.3 of TOP 4-2-502)
- Review of hazards encountered in emplacing and recovering mines
- 12-m drop test
- Extreme temperature storage and functioning
- Packaged drop tests
- Loose cargo tests
- Bare drop tests
- Transportation/vibration tests
- Environmental tests:

*Footnote numbers correspond to reference numbers in Appendix D.

Temperature/humidity cycle
Thermal shock
Salt spray
Rain
Freezing rain
Sand and dust
Water immersion
Weathering
Electromagnetic interference (EMI)
Electrostatic discharge (ESD)

4.4 <u>Sequential Environmental Treatments</u>. In addition to environmental tests conducted during the safety evaluation (TOP 4-2-502), the test director selects from the tests below those that he/she deems necessary, considering requirements, potential use of the item, and previous testing on the same or similar items. Samples of the test items need to be exposed to sequences of extreme environments that the materiel could encounter during its life. Appendix A of TOP/MTP 4-2-015[3] provides a general approach to sequential testing. These environments may include those of TOP 4-2-502. One sequence assumes that the item will be sent to the arctic, another that the item will be sent to the tropics, and another that it will be sent to the desert. After each exposure, all items are examined and a representative sample test-fired. The remainder are sent through the next environments of the sequence.

Test items should contain the minimum explosive loading required to address the effect of an environment on performance and safety. Items exposed to extreme temperatures should include some completely HE-loaded items since extreme temperatures could significantly change the air gap between explosive components or possibly cause melting/exudation of explosives, and thus adversely affect the ability of the fuze to properly initiate the main explosive charge. On the other hand, there is no reason to suspect that salt fog would adversely affect the main charge explosive and therefore no reason to expose fully HE-loaded items to this environment.

The minimum sample size for any exposure is five test items. Any existing data from the developer should be reviewed. The developer's tests should be witnessed and a determination made whether to accept these data in lieu of additional tests, based on the acceptability of the test procedures and results.

4.4.1 <u>High Humidity</u>. Conduct this subtest in accordance with TOP 4-2-820.[4]

4.4.2 <u>Fungus Resistance</u>. Fungus resistance can be ascertained by an examination of the materials composing the mine or demolition, and from certification by the developer that the materials used in the test item are fungus-inert or impregnated with fungus-resistant material. If a fungus test is necessary, MIL-STD-810C[5] or MIL-STD-331[6] is followed.

4.4.3 <u>Salt Spray (Fog)</u>. The salt spray (or salt fog) test is conducted in accordance with MIL-STD-810C.

4.4.4 <u>Sand and Dust</u>. This test is conducted when the possibility exists that sand or dust could interfere with moving parts. The dust test is conducted in accordance with MIL-STD-810C and is applicable only to surface-emplaced items.

There is no standardized sand test; items which are normally buried are therefore buried in sand.

4.4.5 Solar Radiation. This test, which is primarily for heat effects, is conducted as described in TOP 4-2-826.[7] The test items are exposed to the intermediate solar radiation conditions of AR 70-38[8] for 5 days. The test item is then examined and functioned at the equivalent peak temperature (145° F or as otherwise determined).

In view of the high temperature tests of TOP 4-2-502, the solar radiation test may be unnecessary in many cases. It is not necessary to expose a normally buried mine to this treatment.

4.4.6 Immersion. Depending upon the requirements, either of two immersion (waterproofness) tests may be conducted. MIL-STD-331 calls for immersion in water under 15 psi pressure for 60 minutes. A fluorescent solution permits examination for penetration under ultraviolet light. MIL-STD-810C calls for immersion under 91 cm (36 in) of water for 2 hours. For self-contained mines, it may be necessary to conduct a special field test with the mine under water for the duration of its specified field life, after which it is functioned.

4.4.7 Rain and Freezing Rain. An immersion test would normally make a rain test unnecessary. If one is required, however, TOP 2-2-815[9] should be followed; freezing rain tests are also covered therein. (This subtest is especially applicable to mines that deploy triplines.)

4.5 Weathering Test. This subtest is conducted to determine the ability of tactically emplaced mines to withstand exposure to natural environments. It is applicable also to demolitions that would not be functioned immediately after assembly or deployment. The emplacement duration will be the required period specified by the item requirements document. If sufficient samples are available, the desired duration (which would be longer than the required) as well as shorter periods should be investigated.

The explosive content of the test items must be established at a minimal level to permit periodic inspection of the armed items during the emplacement period and recovery of malfunctioned items. The use of fully HE-loaded test items is therefore generally precluded. As a rule, however, the fuze and as many successive elements of the explosive train as possible should be HE-loaded. When performance of the mine or main charge is to be investigated, the HE mine or charge should be weathered with inert fuzes along with HE fuzes on inert mines or charges. Upon completion of the emplacement period, the HE fuzes are disarmed, assembled to the HE mines or charges, armed, and then function tested.

As previously noted, the items are armed upon emplacement. Periodic inspections are made during the emplacement period to determine whether spontaneous functions have occurred.

4.6 Fuze Functioning Test. The purpose of this subtest is to determine the functioning capability and characteristics of the test item. A fuze functioning test is conducted to determine whether the fuze satisfies the performance requirements and whether it is capable of withstanding the effects of shock and environmental conditions that require subsequent fuze operability.

4.6.1 Method. The performance characteristics, a through d below, are determined with unconditioned samples. These samples also serve as control samples for fuzes exposed to shock and other environmental conditions. The ability of a fuze to explosively initiate the next element of the explosive train is considered in paragraph 4.7.

The fuze functioning and compatibility tests are combined when feasible to conserve test hardware.

a. Arming delay time
b. Fuze sensitivity. Whenever practical, a functioning influence of increasing strength should be applied to the armed fuze
c. Antidisturbance sensitivity
d. Self-destruct time

The many types of mines and demolitions preclude the definition of test procedures that would be applicable to all fuzes. Fuze sensitivity and self-destruct performance are normally stressed, and the factors in a and c above must also be considered in any functioning test.

4.6.2 Data Required. Typical data to be recorded are as follow:

a. Arming delay time
b. Fuze functioning load required (may be mechanical or other influence loading [electrical, magnetic, etc.])
c. Degree of tilt required for antidisturbance function
d. Time from arming to self-destruction
e. Number of arming, functioning, or self-destruct successes/failures

4.6.3 Analytical Plan. The probability of functioning under the various conditions should be determined. Additionally, the limiting conditions under which the fuze will function should be tabulated.

4.7 Mine-Fuze Compatibility. This test is conducted to assure that mines and their associated fuzes are compatible with respect to explosive propagation.

4.7.1 Method. Fully loaded HE mines are used in this test. Whenever possible, the fuzes are modified for static initiation so that the time of firing can safely be controlled. At least five samples are used for each possible fuze/mine combination. The order of functioning of the main explosive charge is determined in accordance with TOP/MTP 4-1-003.[10] Scatterable mines, however, contain integral fuzing which then requires testing of the complete item with a minimum explosive loading.

4.7.2 Data Required. Each detonation is recorded as complete or incomplete in accordance with TOP/MTP 4-1-003.

4.7.3 Analytical Plan. Any incomplete detonation is considered a deficiency and must either be explained by the test agency or resolved by the developer.

4.8 Effectiveness Tests.

4.8.1 AT Mines. This test is designed to assure that the effectiveness requirements stated in the requirements document can be met.

4.8.1.1 Method. AT mines are designed to defeat tanks by two means. The blast-type mine immobilizes a tank by breaking the track; it is tested against track only. Mines employing explosive wave shaping are primarily designed to penetrate the armor with the metal liner of the explosive charge, with resulting disastrous consequences to the vehicle and crew; they also have a track-breaking capability when detonated under the track. The armor-penetrating mines are primarily tested against armor. When samples are available, however, tests against tank track should also be conducted with the armor-penetrating mines. Track breaking and armor penetration tests are described separately below.

a. Effectiveness Against Tank Track. The following factors are considered in establishing the test parameters:

(1) Single-pin track is, as a rule, much less vulnerable to mines than double-pin track. The United States uses double-pin track on medium and heavy tanks, while most other countries use single-pin track. Test samples of single-pin track are of necessity generally manufactured from captured samples of foreign track. The resulting supply is scarce and sometimes nonexistent.

(2) Mines are least effective when detonated under the first or last roadwheel of the tank. They are most effective when detonated between roadwheels. The effectiveness at the between-roadwheels location is not significantly greater, though, than under an intermediate roadwheel. Most modern mines are fuzed to detonate beyond the first roadwheel of an armored vehicle. Fuze functioning location data are used in establishing location.

(3) Mines are most effective when centered under the track width; effectiveness decreases as the mine location approaches the track edge. The direction of movement (inboard or outboard from the centerline) is unimportant. The distance from the centerline is the primary variable factor considered in test design. The first mine tested is usually located midway between the track centerline and outboard edge. Subsequent locations are based on the results obtained.

(4) Soil type and condition have a pronounced influence on effectiveness. Clay, for example, significantly increases mine effectiveness and should therefore be avoided in testing the effectiveness of blast-type mines. Using steel plates as targets, limited tests (see reference 20) have shown that 67% more weight of explosive charge is required in dry sand to produce damage equivalent to that caused in wet clay. Dry sand requires 46% more explosive than wet sand. In general, hardness of soil increases mine effectiveness as does saturation of soil with water. Unless otherwise specified, mine effectiveness tests should be conducted in an average dry soil, such as fairly dry sandy loam.

(5) Emplacement depth has an effect on performance and should be that specified for the particular mine. Tests to determine the effect of burial depth on penetration or effectiveness with various types of overburden (soil, leaves, water, etc.) may be necessary to evaluate a test item.

(6) The tank track can be mounted on a target tank or on a test rig that simulates tank-chassis suspension. Use of a test rig can eliminate the time-consuming and expensive repair of the target vehicle suspension system.

To conduct the above effectiveness tests, completely HE-loaded items are used, with the fuze modified for static initiation so that the time of detonation can be safely controlled. The mine is emplaced at the specified depth and located so that it will be at the desired location under the vehicle or test rig. When a target vehicle is used, the mine should be emplaced in the vehicle path and the vehicle pulled over the mine. Damage to the track and vehicle suspension system is recorded following detonation. Photographs, measurements of striking points, hole diameters and depths, and assessment of damaging effects (especially for tracks) are the main data to be taken.

b. Armor Plate. Fully loaded HE mines modified for static initiation are again used in this test. The mines are emplaced under armor plate at the normal standoff, with the underside of the plate parallel to and 46 cm (18 in) above the soil surface or at any alternately specified distance. Rolled homogeneous armor plate is used unless otherwise specified by the requirements document. Unless specified otherwise, use 7.6-cm- (3-in-) thick plate. Mine cant may also be evaluated as a factor in effectiveness, especially for scatterable mines. The effects of mine cant and overburden on mine performance are very important evolution factors for mine armor penetration capability. Photographs, measurements of striking points, hole diameters and depths, and spall assessment are the main data to be recorded.

c. Magnetic Influence Tests. AT mines that depend on the magnetic field surrounding a target vehicle for signature effects require special tests to determine their sensitivity and the effect of varying background magnetic fields (upon mine performance) such as those that naturally occur in various parts of the world. A special magnetic test facility exists at APG whereby:

(1) An outdoor array of coils can be used to vary the local magnetic field strength to simulate that of any global latitude and longitude.

(2) Inert instrumented mines can be emplaced on or under a roadway and connected to data-processing and display devices contained in the control room (B-459).

(3) When target vehicles of interest are driven over the mines, mine functioning is automatically noted and displayed with regard to relative location on the vehicle hull.

(4) Tests are conducted by varying parameters of interest, including background field strength, vehicle type and speed, and mine sensitivity.

4.8.1.2 Data Required. Armor plate damage is recorded as described in TOP 2-2-710.[11] Record damage to track, belly armor, and internal components. When incomplete breakage occurs, record the percent of the total track width defeated. Also record a description of the soil.

4.8.1.3 Analysis of Results. Performance against tank track is analyzed in terms of the probability of damage sufficient to immobilize the tank (often called a mobility kill) occurring as a result of mines randomly encountered across the full width of the track. Track breakage is categorized as complete (both pins), partial (one pin), or none.

Performance against armor plate is analyzed in terms of the probability of an open break in the armor occurring. Possible effect on personnel is assessed.

4.8.2 AP Mines. This subtest is conducted to evaluate the effectiveness of AP mines in accordance with requirements and other requirements as directed or deemed necessary. Fragmentation tests for munitions are described in TOP 4-2-813.[12] Mine-peculiar tests are described below.

4.8.2.1 Method. Fully loaded HE AP mines, modified for static detonation, are used. Methods applicable to each of the three types of effects considered are specified below.

a. Fragmentation Mines. There are three types of fragmentation mines: (1) an explosive encased in metal which is placed on or in the ground and usually detonated by a tripline or by foot pressure, (2) a linear explosive charge with a convex face that is lined with pre-formed fragments. After command detonation, fragments are dispersed in an acute angle essentially parallel to the ground (the Claymore is such a mine), and (3) a bounding mine which is buried in the ground and which, upon initiation, causes a propellant charge to throw the warhead portion of the mine into the air. Functioning usually occurs at a height of 1.2 to 1.8 m (4 to 6 ft). (The M16 is such a mine; at one time it was called the "bounding Betty.") The bounding mine (App. B) is sometimes detonated against vehicular armor in the manner described in TOP 2-2-617[13] and reference 21.

Velocity, weight, and distribution of fragments are determined in accordance with TOP 4-2-813. Lethal area computations are made when required. A sample of three mines is required for each realistic positioning of the mine: i.e., on the ground for most mines but several feet in the air for bounding mines.

b. Blast Mines. Although MTD measures blast, the effectiveness of these mines is determined by the Target Assessment Branch of the US Army Ballistics Research Laboratory, Aberdeen Proving Ground, based on blast-measurement data (TOP 1-2-608[14]).

c. Shaped Charge Mines. Penetration data are taken as described herein. Effectiveness is evaluated using these data.

4.8.2.2 Data Required. The conditions under which the mine was detonated and detailed descriptions of the targets before and after mine detonation are recorded. In the case of fragmenting mines, data are presented in the manner of TOP 4-2-813 and lethal areas computed.

4.8.3 Demolition Charges. This subtest is conducted to evaluate the effectiveness of demolition charges in accordance with requirements. The measure of effectiveness depends on the purpose for which the demolition will be used. Two important factors must be considered in determining demolition effectiveness: the effects of soil conditions on crater size, and the dependence of preparation time on shaped charge performance in different road materials. In tests conducted at Fort Peck, Mt, and APG, Md, the Fort Peck crater (created in highly weathered shale) was about one-half as deep and three-fourths as wide as the APG crater (created in wet sandy silt).

4.8.3.1 Method. Effectiveness of a demolition charge is usually based on comparison with TNT which is arbitrarily rated as 1.00 (see App. C, Table C-2, and FM 5-25, ch. 1). Effectiveness can also be measured by comparison with other demolitions or by measuring detonation velocity when the latter is an important factor relative to the effects desired from the demolition. Table 1-1 of FM 5-25 (summarized in App. C) lists characteristics of 14 different types of explosives used by the Army, including the velocity of the detonation to be expected from each. The six general uses to which these demolitions are applied (FM 5-25) are: timber cutting, steel cutting, pressure (reinforced concrete, T-beam bridges, cantilever bridges), breaching (concrete slab bridges, piers, and permanent field fortification), cratering and ditching, and land clearing and quarrying. Methods for setting up the tests for these applications are also provided in FM 5-25. The specific method to be used depends upon the particular item being tested and the criteria listed in the requirements documents or the test directive. Tests of demolition-initiating equipment are covered in TOP 4-2-045.[15] Additional background and procedural information on use of larger demolition charges for cratering effects is given in TOP 4-2-830.[16]

The item is tested in the manner in which it is intended to be employed. Thus, if the item is intended to breach barbed wire, it is tested in a realistic manner against typical military barbed wire configurations. If it is intended to cut a certain size timber, it is so tested, etc. A typical example of a test of a demolition designed as a cratering charge is as follows. The objectives of the test are:

a. To determine whether the kit can safely and reliably produce a crater at least 4.6 m (15 ft) in diameter (7.6 m [25 ft] desired), 2.1 m (7 ft) deep, and with side slopes of at least 30°.

b. To determine whether an effective obstacle to tracked and wheeled vehicles can be produced by three kits in a road 6 m (20 ft) wide and five kits in a 9-m (30-ft) road. An effective obstacle would require at least three attempts by an M60-series tank to surmount the obstacle.

Forty-three kits are required for this test. They are expended in groups of one, three, and five against reinforced concrete roads and soil.

For the craters produced by single kits, the diameter is measured along two perpendicular axes and the depth is measured at both the 1/4- and 1/2-diameter points. For the obstacles produced by three and five kits, enough measurements are taken to be able to obtain comparative results. The failure of the tank to cross or the number of attempts required to cross (up to a maximum of six) is recorded. During a representative sample of the employment, the total time to make the kit ready for firing is recorded (both with and without arctic clothing).

4.8.3.2 Data Required. Record the following: The specific characteristics of the target (road, soil, fortification, equipment, beam, mine field, etc.) against which the demolition is employed; the exact positioning of the demolition and the type of fuze. After the demolition is detonated, record detailed information on results and assess the effectiveness of the demolition. (In the cratering-charge example, for instance, note the attempts of the tank to climb out of the crater and the results.) Record time required to produce each road crater.

4.8.3.3 Analytical Plan. The results are conveniently tabulated, and where information exists, comparisons are made with other demolitions.

4.9 Bullet Impact Test. Conduct this subtest to determine the effects of bullet impact on the safety of the mine or demolition device.

4.9.1 Standards. Standards for acceptability are contained in the requirements documents and other guidance documents.

4.9.2 Method. Determine the following test details:

a. Number of test items to be impacted
b. Packaging (packaged or bare)
c. Caliber and type of ammunition

The firing distance, if not specified, is generally an acceptable compromise between the distance that provides a high degree of assurance that the target can be hit and the distance at which the equipment at the firing position is reasonably safe from a test item detonation.

Selected small arms ammunition is fired into the test items, and observations are made for complete or partial detonation of the test items and for low or high order detonations.

4.9.3 Data Required. Record the following:

a. Number, type, and caliber of rounds fired, with weight of bullet in grains
b. Location and results of each impact, including high or low order detonation
c. Distance to target and estimated (or measured) terminal velocity
d. An evaluation, if detonation does not occur, of safety of disposal

4.9.4 Analytical Plan. The results obtained are compared to the requirements document criteria. If no criterion exists, the results are presented for informational purposes.

4.10 Blast Sensitivity, Sympathetic Detonation, and Vulnerability Test. Conduct this subtest on armed mines and demolitions to determine their susceptibility to blast or sympathetic detonation. Perform other vulnerability tests as required to assess counter-countermeasure effectiveness of mines and demolitions.

4.10.1 Standards. Standards for acceptability are contained in the requirements document or other guidance documents. For manually emplaced mines, the detonation of one mine should not set off an adjacent mine.

4.10.2 Method. Two types of blast sensitivity tests should be considered. For reasons of safety, the mines exposed to detonation will normally have an inert booster and main charge.

a. Blast Sensitivity - To determine the effects of explosions on an armed test item. The charge that is purposely detonated may be different from that of the test item, and both the charge weight and the distance from the charge to the test item may be varied. This test can be used to simulate a condition in which enemy artillery is used to destroy a mine field.

For the blast sensitivity test, the charges to be detonated are placed at the prescribed distance from the mine (or demolition). When appropriate, additional charges are detonated at various distances in an attempt to bracket the critical distance for detonation. Blast overpressure measurements are made for each test shot, as prescribed in TOP 4-2-822.[17]

b. Sympathetic Detonation - To determine whether the specified separation distance between mines/demolitions will preclude the functioning or damaging to the extent of inoperability of armed test items from the effects of the detonation of another item.

For the sympathetic detonation test, the test items are tactically emplaced, completely live with fuzes armed, at the prescribed minimum separation distance from a test item that has been fixed for static detonation. At least three test items, separated 120° apart, should be used to surround the mine to be detonated.

c. Vulnerability - In addition to vulnerability data gleaned from the blast sensitivity and sympathetic detonation tests, further specific tests may be necessary to evaluate the effects of known mine-clearing techniques (in some cases, the required data can be accumulated in conjunction with conducting other specific subtests). A description of some commonly employed countermeasures is as follows.

(1) Avoidance - Throughout testing, visual observations of mines and triplines are made when deployed on barren earth, low and high vegetation. Data from tripline effectiveness studies are also used. Visual sighting of the mines and triplines is recorded by having at least 10 soldiers pass through a simulated mine field emplaced on barren high- and low-vegetation terrains. Tripline effectiveness tests that establish the minimum force at which a soldier can sense the presence of a tripline are compared to the tripline pull force required to actuate the mine.

(2) Thermal - The effects of fire on the mines and triplines are determined by emplacing mines in a grassed area and setting fire to the area. The data recorded include: the number of mines that detonate because of the fire, the effect on the triplines (if any triplines remain and if so, will they activate the mine), and whether the mine will still detonate due to disturbance or other prime fuze sensor.

(3) Small arms fire - A small mine field is emplaced using five full-HE mines. One sharpshooter (rifleman) attempts to clear the mine field by shooting the visible mines, as described in para 4.9.

(4) Artillery fire - A full-HE artillery projectile (155mm or as specified) is set up for static ground-level detonation. Mines are emplaced at various distances from the round. Visual and photographic observations are made of the results when the artillery projectile is detonated. The detonation of any mine is recorded. The cleared area from the artillery blast is measured. Recoverable or visually sighted mines are then tested for functioning performance.

(5) HE line charge - An M173 line charge (or as specified) is emplaced and a mine field is laid over the emplaced line charge or section thereof. Emplacing the line charge before the mine field (while tactically reversed) is

for safe testing purposes only. Visual and photographic observations are made of the results when the line charge is fired. The detonation of any mine is recorded. The cleared area from the line charge blast is measured and compared to requirements. Recoverable or visually sighted mines are tested for functioning performance. An additional test may be conducted by placing one section of the line charge over an armed fully HE mine, initiating the mine, and recording whether the line charge is also initiated.

(6) Grapnel - Five or more personnel equipped with grapnels are instructed to clear a path through a simulated mine field. The time required to clear a foot path through the mine field is recorded and the path is inspected to ensure that it has been effectively cleared. The results of this test are combined with the visual avoidance test data and lethal range data to determine vulnerability to grapnels. The procedures to be used are in accordance with the Combat Engineers' Field Manual (FM 20-32, page 116).

(7) Mine-clearing roller or plow - Effectiveness of these special-purpose devices in clearing a mine field is evaluated by clearing inert-loaded practice mines or minimum explosive-loaded mines. Effect of a mine detonation on the clearing device is determined by a static detonation test shot.

(8) Electronic devices or equipment - Test the effectiveness of these types of countermeasure equipment on mines with electronic components.

4.10.3 Data Required. Record the following:

a. Parameters and configuration of the test setups
b. Results after each static firing, test shot, or exercise
c. Blast overpressure data, if not previously obtained

4.10.4 Analytical Plan. Prepare a sketch to illustrate the parameters and test configuration. Test results are examined to determine conformance with requirements.

4.11 Parachute Delivery Test. If a specific requirement for aerial delivery is contained in the guidance document, conduct a parachute delivery test in accordance with TOP 4-2-509.[18]. Engineering judgment is used as the basis for determining whether the drop should be actual or simulated. When no requirement for aerial delivery is stated, engineering judgment is used to determine whether a parachute delivery test is necessary.

4.12 Reliability. When a reliability requirement is stated, use TOP/MTP 3-1-002[19] to determine sample size and to determine whether the desired functioning reliability is achieved with the desired confidence. A precise definition of satisfactory performance is a prerequisite to a reliability analysis. Two reliability analyses are made: (a) overall reliability which includes a summation of all the satisfactory and unsatisfactory samples of each subtest and (b) selected reliability which includes all sample groups except those in which the test items suffered damage or deterioration during environmental or rough handling tests and groups in which statistically significant failures occurred in a particular subtest. For mines that have multiple modes of operation and/or functioning, the reliability test can become quite complicated. In any case, the reliability test needs to be planned and executed using a sound statistically based approach so that maximum information can be obtained from the available test samples.

4.13 Human Factors Evaluation. The human factors evaluation, like the reliability analysis, is categorized as a separate subtest, but it is conducted throughout the test program in accordance with TOP 1-2-610.[22] It involves determining the ease with which all of the functions such as unpacking, fuzing, arming, etc., can be performed under day/night conditions and while personnel wear protective clothing and equipment. When problem areas are encountered, recommendations should be made regarding improvements.

4.14 Logistic Supportability. Logistic supportability is also categorized as a separate subtest but is conducted throughout the entire test. This may include an evaluation of tools and equipment, equipment publications, and design for maintainability. Logistic efficiency is particularly important to engineer units that must transport their Class V materials over long distances. For planning use, the weights and volumes of packaged charges, as well as the weight and volume of mines should be considered.

5. DATA REDUCTION AND PRESENTATION.

a. Assemble, reduce, and summarize raw test data in accordance with the requirements stated herein and in each referenced TOP. Processing will include but not be limited to the following elements:

(1) Identification data for each test specimen, each test facility, and each measurement system

(2) Complete data on the test results: functioning/nonfunctioning of each test item, including penetration/nonpenetration, blast data, crater or hole sizes, and other data pertinent to test objectives.

(3) Comprehensive description of test conditions

(4) Photographs for permanent documentation of significant test results and procedures

(5) Complete description of any safety incidents and/or hazards encountered, with appropriate restrictions, warnings, or design changes indicated

b. Organize the test data into appropriate tables and graphs. Compute the mean and standard deviation of all numerical values for each parameter measured, and determine the effect of environmental factors. Compare performance data with the requirements and evaluate narratively in a comprehensive test report.

Recommended changes of this publication should be forwarded to Commander, US Army Test and Evaluation Command, ATTN: DRSTE-AD-M, Aberdeen Proving Ground, Md. 21005. Technical information may be obtained from the preparing activity: Commander, US Army Aberdeen Proving Ground, ATTN: STEAP-MT-M, Aberdeen Proving Ground, Md 21005. Additional copies are available from the Defense Technical Information Center Cameron Station, Alexandria, Va. 22314. This document is identified by the accession number (AD No.), printed on the first page.

APPENDIX A

BACKGROUND

Land mines can be divided into two general types: antitank (AT) and antipersonnel (AP). In the past, most land mines were designed to be buried just beneath the surface of the ground, although some varieties could be placed on the ground. The current trend is toward design for placement on the surface. Also known as scatterable mines, these surface-emplaced mines are the subject of considerable development; materiel is being designed to permit emplacement of these mines (either AT, AP, or a mix) by powered or hand-operated mobile dispensers, by artillery fire, or from rotary-wing or fixed wing aircraft. The scatterable mines may themselves contain advanced electronic features and options such as settable self-destruct time delays and primary, backup, and anti-disturbance sensing and functioning options.

A mine is a fuzed munition designed to function (explode) when a target comes within lethal range. Mines vary significantly in complexity and sophistication. The oldest type of AT mine, still in wide use, is the manually emplaced buried blast-type mine functioned when the target applies a sufficient force on the pressure plate. The newer mines are generally mass-scatterable; these mines automatically arm during the scattering process. A listing of various mine and fuze features is contained in Appendix C, along with similar information for demolitions. The older manually emplaced mines are inefficient and typically only suitable for use in relatively static defensive situations. Modern scatterable mines are designed for offensive and defensive use on the modern dynamic battlefield.

Mines and demolitions are similar in many ways, and can sometimes be used interchangeably for certain specific applications. Mines are configured as a munition with self-contained arming and activating devices, and usually depend on some effect in addition to explosive brisance (i.e., fragmentation of munition body, use of a shaped or plate charge) to enhance terminal effectiveness and performance. Mines may be configured to direct their destructive force in a particular direction, e.g., upward or laterally.

Demolition devices are more typically used to destroy structures such as buildings, bridges, dams, earthworks, and other fortifications or terrain features. Demolition charges are most commonly assembled as needed from standard initiating components and blocks of demolition explosives or other standard charges. However, special purpose demolition kits that exist for clearing mine fields, destroying air fields, etc., are packaged with all necessary materiel (but not necessarily pre-assembled). Often, these kits contain a means of projecting the explosive, as over a mine field or obstacle, as well as the other required functions of arming and detonating.

All AT mines rely upon explosive content for their effectiveness; some, however, may contain an explosive in a configuration that will concentrate the destructive force in one direction. Such is the case with the shaped charge mine (Monroe effect) which contains a conical cavity with liner in the explosive charge, and the plate-charge mine (Misznay-Schardin [M-S] effect) in which the explosive is positioned against the convex side of a metal plate (e.g., the M-21). Both the shaped charge and the M-S plate are devices that cause portions of the liner or plate to be re-formed and accelerated to hyper-velocity levels. Upon striking armor plate or another applicable target surface, penetration of the belly armor and defeat of the tank or vehicle can be achieved.

AP mines also rely upon explosive energy. Some have no significant casing while others are encased in metal that will fragment. The bounding mine is a variety that launches an explosive warhead a few feet into the air where it can be more effective upon detonation.

APPENDIX B

BURST HEIGHT DETERMINATION FOR BOUNDING MINES

This appendix describes a method of recording the burst height of antipersonnel bounding mines on Polaroid film. The projectile burst is recorded, along with height reference markings, during a time exposure made with a neutral density filter. The filter limits the recorded image of the detonation flash to the most brilliant portion originating from the projectile, thus permitting identification of the projectile location at the time of detonation. The filter also permits sufficient light to pass during the time exposure (about 3 seconds) so that background details, including height reference markings, are recorded.

The content of this appendix is based on a study to develop a method of determining burst heights that would be as accurate as and less expensive than high-speed photography.

1. Equipment Required. A still camera with time-exposure and Polaroid film is necessary. The lens focal length must, however, be greatly increased by the addition of a telescope lens or similar optic device. A lens focal length of at least 254 cm (100 in) is considered necessary so that the camera can be positioned at a safe distance from the mine and still produce an optimum field of view. A separation distance of at least 76 m (250 ft) between mine and camera and a field of view of 3 m (10 ft) at this distance is needed. The components used in assembling the unit shown in Figure B-1 were selected to an extent on the basis of availability, and are not necessarily optimal. Comments are therefore provided on the suitability of each component used.

a. PH-47J Camera. This camera is used because it incorporates the following features: 1) a ground-glass viewing screen; 2) a time-exposure capability. The camera unit is positioned immediately adjacent to a personnel shelter (bombproof) and a cable release used to control the camera shutter from within the shelter.

b. Polaroid Land No. 500 Filmholder. This permits the use of sheet film so that the holder can be removed whenever use of the ground-glass viewing screen is desired.

c. M49 Telescope. This 20-power telescope, along with the camera 5-inch lens, is used so that the desired focal length of 254 cm is attained. A variable power telescope is desirable to allow flexibility in changing the field of view.

d. Kodak No. 96 Neutral Density Filters. Three filters with density values of 0.50, 1.00, and 2.00 are sufficient when either black and white or color film is used. The percent of light transmitted by the filters is 32, 10, and 1, respectively. Glass filters are recommended since gelatin filters are easily damaged by moisture or handling.

e. Camera Tripod. A rigid and readily adjustable tripod is required.

f. Improvised Mount. A plywood base, bolted to the tripod head, is functionally adequate. The camera is bolted to the plywood and the telescope held by two pipe clamps. An improvised filter mount is used to hold the filters on the telescope. The mounts must permit focusing adjustment of the camera lens.

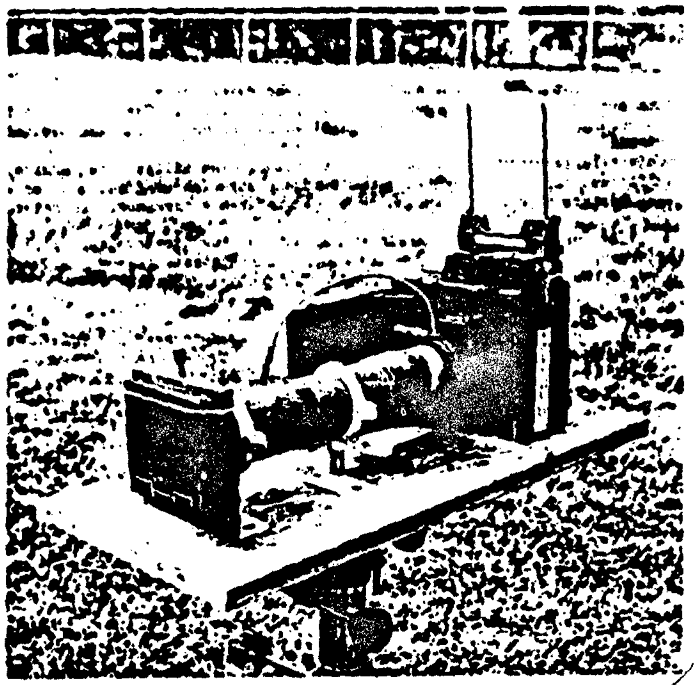

Figure B-1. Assembled equipment for photographing burst height.

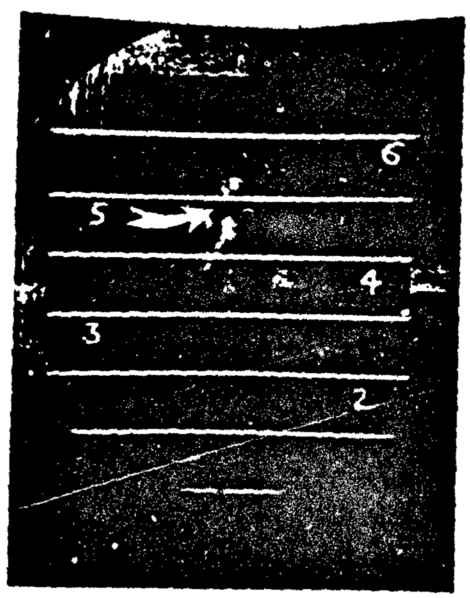

Figure B-2. Photograph of projectile burst.

g. Background Screen. A black background is required to provide the contrast necessary for easy location of the projectile burst. The background evident in Figure B-2 is a 2.4-m-square (8-foot-) plywood panel painted flat black. The panel is located about 15 m (50 ft) beyond the mine. The distances between the horizontal white strips are scaled to represent .3-m (1-ft) increments at the mine position.

h. Film. Polapan type 52 (black and white) and Polacolor type 58 sheet film are used. Color film is recommended, however, because it permits easier identification of the burst.

2. Procedure. The following steps are taken:

a. Assemble the tripod, mount, and camera.

b. Open both the lens aperture and shutter. (The aperture is to remain open at all times.)

c. Using the ground-glass viewing screen, align the camera with the mine firing position.

d. Adjust the separation distance between the telescope eyepiece and the camera lens until a sharp image is obtained on the ground-glass viewing screen. Secure the items in this position and seal the juncture from light with opaque tape.

e. Close the camera shutter and install the filter(s) on the telescope. A 2.00 density value filter is installed if black and white film is used. A test photograph is suggested at this point to check system operability and camera alignment. This is accomplished by making a 3-second exposure.

f. Emplace the mine and prepare it for remote fuze actuation.

g. Open the camera shutter. The mine fuze must be ready for actuation immediately after shutter opening.

h. Actuate the mine fuze.

i. Close the camera shutter as soon as the mine detonates (a total exposure time of 3-5 seconds is normal).

j. Develop the film.

k. Visually examine the resulting photograph to determine the projectile burst location. The burst will generally appear on the film as recorded streaks of light spreading outward from a central area having the approximate dimensions of the projectile. The burst of an M16 mine projectile is indicated by the arrow in Figure B-2.

l. Repeat steps f through k for subsequent firings.

APPENDIX C

TYPES OF MINES, DEMOLITIONS, AND EXPLOSIVES

Table C-1 illustrates the variety of effects and sensing devices involved with mines and demolitions. Detailed descriptions of standard items are contained in TM 43-0001-36 and FM 5-25.

TABLE C-1
TYPES AND SENSING METHODS FOR MINES AND DEMOLITIONS

	Antitank Mines	Antipersonnel Mines	Demolitions
Types of Effects	Blast Chemical Shaped charge Plate charge Implosive fragmentation	Blast Chemical Shaped charge Bounding fragmentation Fixed fragmentation	Blast Shaped charge
Types of Sensing	Acoustical (noise) Attenuation or cutting, e.g., a beam of light Infrared Magnetic Pressure Vibration Combinations Disturbance Self-destruct	Command, i.e., fired by friendly forces Pressure Pull (tripwire) Disturbance Self-destruct	Command Acoustical Chemical delay Clock delay Concussion Pressure Pressure/release Pull Pull/release Release

Table C-2 contains a listing of explosives used for demolitions extracted from FM 5-25. Additional details on the properties of these explosives are contained in AMCP 706-177.

TABLE C-2
TABLE OF EXPLOSIVES COMMONLY USED FOR DEMOLITION PURPOSES

Name	Composition	Mainly Used In	Velocity of Detonation, Propagation meters/sec	Relative Effectiveness as a Breaching Charge[a]	Intensity of Poisonous Fumes	Water Resistance	Max. Temp. for Safe Storage, °C
Ammonium Nitrate	100% NH_4NO_3	Demolition charge, comp explosives	2,700	—	Dangerous	None	66
PETN	100% Pentaerythritol tetranitrate	Detonating cord, blasting caps, demolition charge	8,300	1.66	Slight	Excellent	66
RDX	100% Cyclonite (RDX)	Blasting caps, comp explosives	8,350	1.60	Dangerous	Excellent	71
TNT	100% Trinitrotoluene	Demolition charge, comp explosives	6,900	1.00	Dangerous	Excellent	66
Tetryl	100% Tetryl	Booster charge, comp explosives	7,100	1.25	Dangerous	Excellent	66
Nitroglycerin[b]	100% Nitroglycerin	Commercial dynamites	7,700	1.50	Dangerous	Good	—
Black powder	74.0% Potassium nitrate; 10.4% sulphur; 15.6% charcoal	Time blasting fuse	400	0.55	Dangerous	Poor	71
Amatol 80/20	80% NH_4NO_3 20% TNT	Bursting charge	4,900	1.17	Dangerous	Very poor	66
Composition A3	91% RDX 9% wax	Booster charge, bursting charge	8,100	—	Dangerous	Good	71
Composition B[c]	60% RDX 40% TNT 1% wax	Bursting charge	7,800	1.35	Dangerous	Excellent	71
Composition C3	77% RDX; 3% Tetryl; 4% TNT; 10% DNT; 5% MNT; 1% NC	Demolition charge	7,625	1.34	Dangerous	Good	[d]—
Composition C4[c]	91% RDX; 9% Plasticizer, nonexplosive	Demolition charge	8,040	1.34	Slight	Excellent	71
Tetrytol 75/25[c]	75% Tetryl 25% TNT	Demolition charge	7,000	1.20	Dangerous	Excellent	66
Pentolite 50/50	50% PETN 50% TNT	Booster charge, bursting charge	7,450	—	Dangerous	Excellent	66

[a]Compared with TNT = 1.00.
[b]Nitroglycerin is stable at temperatures below 50° C; at higher temperatures, it decomposes rapidly. It must be stored in buildings specially constructed for it, and it must be kept under constant surveillance.
[c]Also used in mines; may exude when stored above 66° C.
[d]Composition C3 should not be stored at elevated temperatures (above room temperature).

APPENDIX D

REFERENCES

1. Test Operations Procedure (TOP) 4-2-502, Safety Evaluation of Mines and Demolitions, 5 May 1978.

2. TOP 4-2-500, Ammunition Characteristics, 9 November 1981.

3. Materiel Test Procedure (MTP) 4-2-015, Close Support Rockets and Missiles, 1 March 1971.

4. TOP 4-2-820, Humidity Tests, 1 April 1979.

5. MIL-STD-810C, Environmental Test Methods, 10 March 1975.

6. MIL-STD-331, "Fuze and Fuze Components, Environmental and Performance Tests for", 15 October 1976.

7. TOP 4-2-826, Solar Radiation Tests, 15 October 1979.

8. AR 70-38, Test and Evaluation of Materiel for Extreme Climatic Conditions, 1 August 1979.

9. TOP 2-2-815, Rain and Freezing Rain, 19 June 1975.

10. TOP/MTP 4-1-003, Order of Functioning, 23 February 1966.

11. TOP 2-2-710, Ballistic Tests of Armor Materials, 6 April 1977.

12. TOP 4-2-813, Static Fragmentation Tests of High-Explosive Munitions, 31 January 1980.

13. TOP 2-2-617, Armored Vehicle Vulnerability to Conventional Weapons, 30 January 1975.

14. TOP 1-2-608, Sound Level Measurements, 17 July 1981.

15. TOP 4-2-045, Demolition-Initiating Equipment, 2 February 1972.

16. TOP 4-2-830, Explosive Cratering Performance Tests, 2 July 1981.

17. TOP 4-2-822, Electronic Measurement of Airblast Overpressure, 28 September 1981.

18. TOP 4-2-509, Airdrop Capability of Explosive Materiel, 1 November 1972.

19. TOP/MTP 3-1-002, Confidence Intervals and Sample Size, 25 January 1967.

20. Eddy, J.R., "Final Report on Special Study of Effect of Soil Conditions on Mine Blast", TECOM Project 9-CO-001-000-047, Aberdeen Proving Ground, Md., Report APG-MT-4136, January 1973.

21. VanCaneghem, Rene, "Final Report on Special Study of Data Analysis to Develop Standardized Mine Test for Lightly Armed Vehicles", TECOM Project 9-CO-001-000-041, Aberdeen Proving Ground, Md., Report APG-MT-4002, February 1972.

22. TOP 1-2-610, Human Factors Engineering (Part I - Procedures, Part II - Hedge), 20 December 1977.